



US009210703B2

(12) **United States Patent**  
**Osborn**

(10) **Patent No.:** **US 9,210,703 B2**  
(45) **Date of Patent:** **\*Dec. 8, 2015**

(54) **SYSTEM, METHOD, AND  
COMPUTER-READABLE MEDIUM FOR  
IP-FEMTOCELL PROVISIONED RADIO  
ACCESS NETWORK**

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 44 days.

This patent is subject to a terminal dis-  
claimer.

(21) Appl. No.: **13/964,194**

(22) Filed: **Aug. 12, 2013**

(65) **Prior Publication Data**

US 2013/0329671 A1 Dec. 12, 2013

**Related U.S. Application Data**

(63) Continuation of application No. 13/338,357, filed on  
Dec. 28, 2011, now Pat. No. 8,526,369, which is a  
continuation of application No. 12/252,199, filed on  
Oct. 15, 2008, now Pat. No. 8,103,274.

(60) Provisional application No. 61/003,151, filed on Nov.  
15, 2007.

(51) **Int. Cl.**  
**H04W 4/00** (2009.01)  
**H04W 72/04** (2009.01)  
**H04W 76/02** (2009.01)  
**H04W 40/20** (2009.01)  
**H04L 29/06** (2006.01)

*H04W 84/04* (2009.01)  
*H04W 88/08* (2009.01)

(52) **U.S. Cl.**  
CPC ..... **H04W 72/0426** (2013.01); **H04L 65/104**  
(2013.01); **H04W 40/20** (2013.01); **H04W**  
**72/04** (2013.01); **H04W 72/0406** (2013.01);  
**H04W 76/02** (2013.01); **H04W 76/022**  
(2013.01); **H04L 65/1006** (2013.01); **H04W**  
**84/045** (2013.01); **H04W 88/085** (2013.01)

(58) **Field of Classification Search**  
None  
See application file for complete search history.

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(57) **ABSTRACT**

A system, method, and computer readable medium for pro-  
visioning radio access via a femtocell system that includes  
integrated BTS and BSC functions are provided. The femto-  
cell system is coupled with a packet switched backhaul and  
provides an IP-accessible radio access network. The femto-  
cell system includes a session initiation protocol adapter that  
supports a SIP client pool and provides conversion of call  
set-up functions to SIP client set-up functions for provision-  
ing of radio access to a user equipment. The user equipment  
may have a session initiation protocol client associated with  
the user equipment. The session initiation protocol client is  
hosted and registered with a registrar service by the femtocell  
system. Accordingly, telecommunication services may be  
directed to and from the user equipment over the packet-  
switched backhaul to the user equipment via the femtocell  
system.

**15 Claims, 5 Drawing Sheets**

600

610—REGISTER sip:example.com SIP/2.0  
Via: SIP/2.0/UDP  
From: sip:12145551212@example.com  
To: sip:12145551212@example.com  
612—Contact: sip:12145551212@66.249.73.42  
614—Contact: tel: +1-214-555-1212

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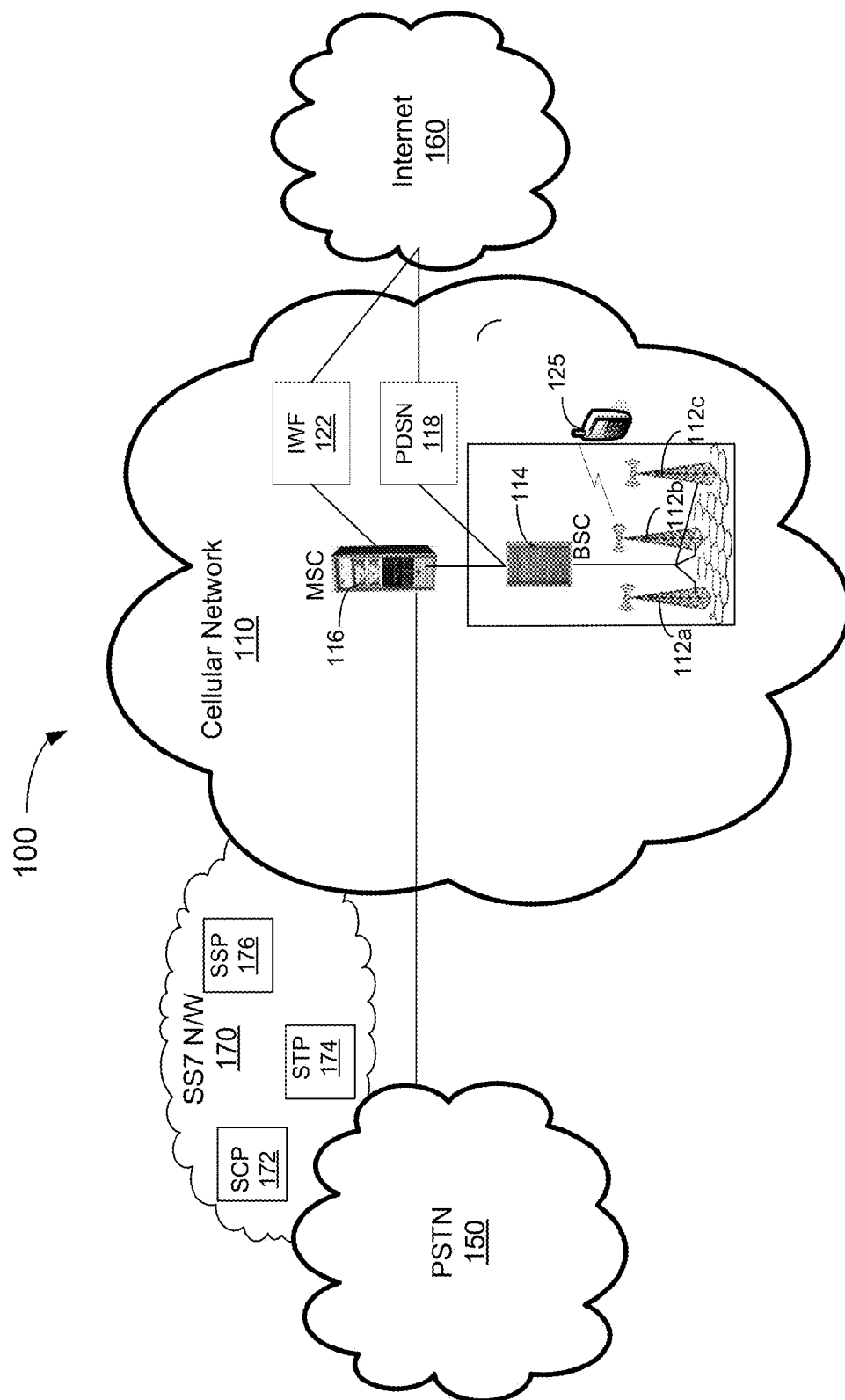


Figure 1

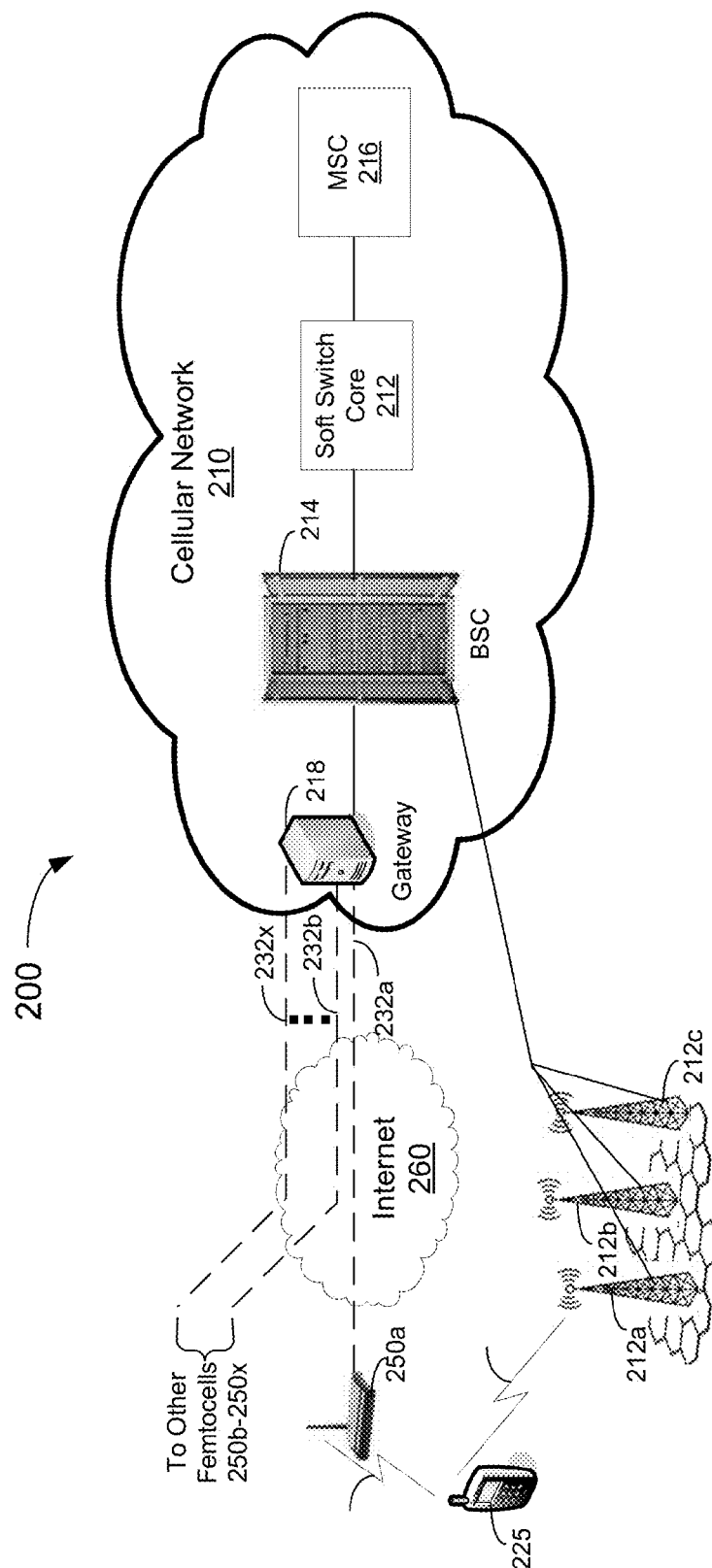


Figure 2

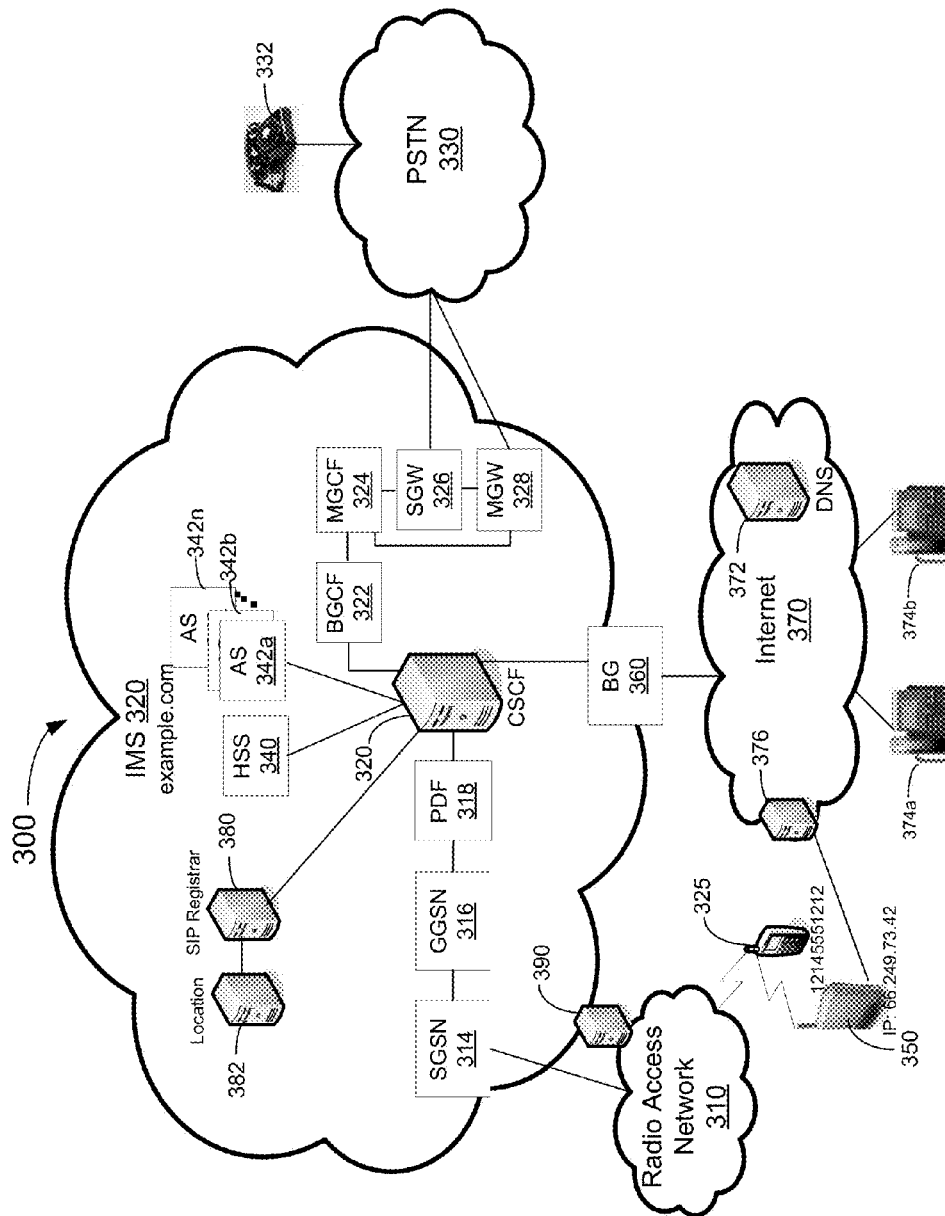


Figure 3

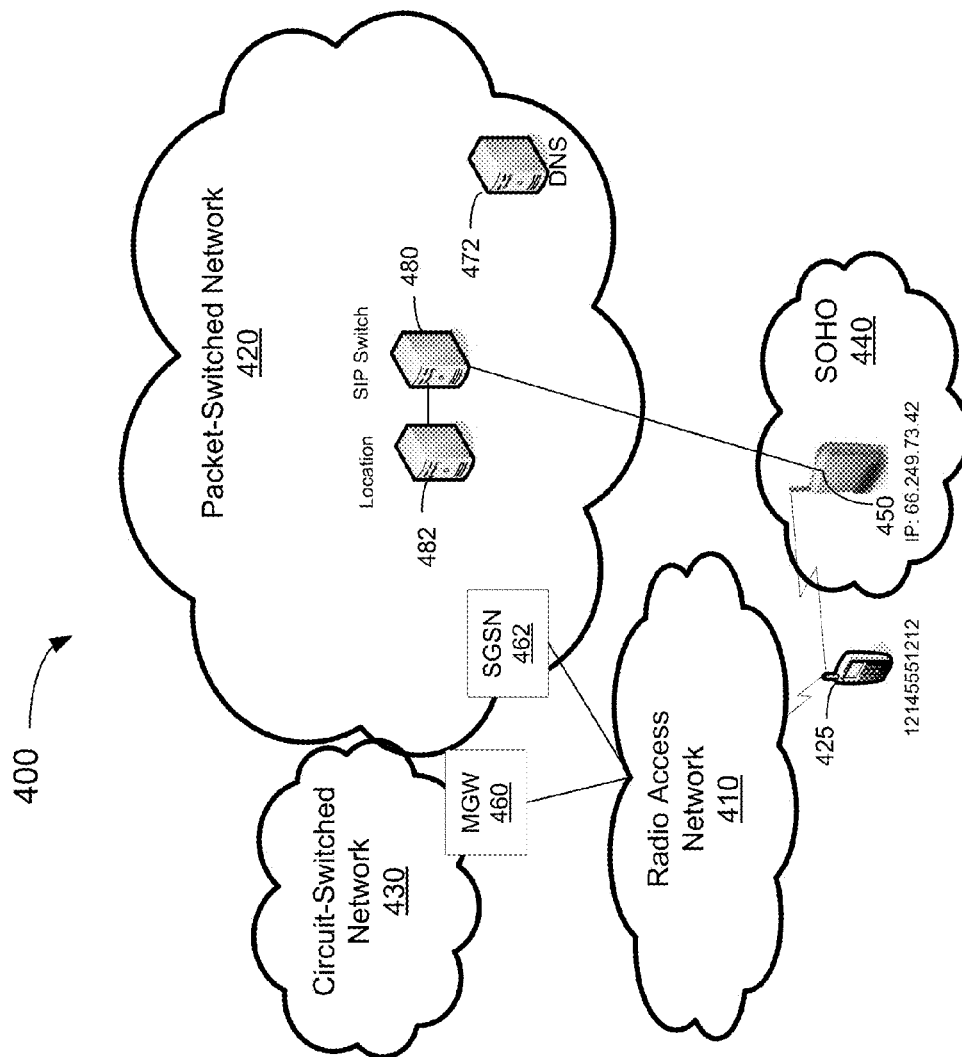


Figure 4

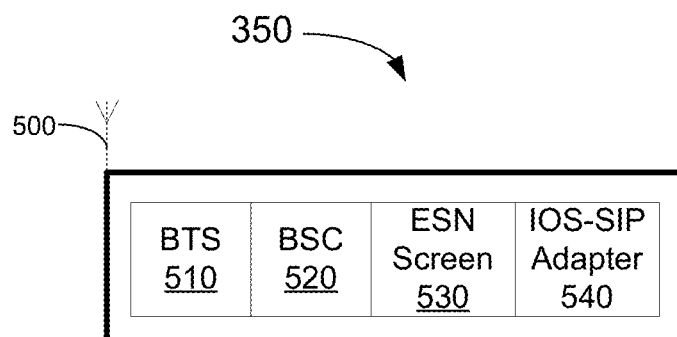


Figure 5A

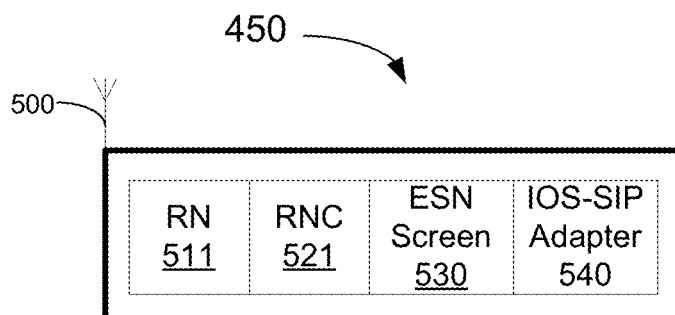


Figure 5B

600

610—REGISTER sip:example.com SIP/2.0  
Via: SIP/2.0/UDP  
From: sip:12145551212@example.com  
To: sip:12145551212@example.com  
612—Contact: sip:12145551212@66.249.73.42  
614—Contact: tel: +1-214-555-1212

Figure 6

# 1

## SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR IP-FEMTOCELL PROVISIONED RADIO ACCESS NETWORK

### CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. patent application Ser. No. 13/338,357, entitled SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR IP-FEMTOCELL PROVISIONED RADIO ACCESS NETWORK, filed on Dec. 28, 2011, which is a continuation of U.S. patent application Ser. No. 12/252,199, entitled SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR IP-FEMTOCELL PROVISIONED RADIO ACCESS NETWORK, filed on Oct. 15, 2008, now issued U.S. Pat. No. 8,103,274, issued on Jan. 24, 2012, and claims priority to U.S. provisional patent application Ser. No. 61/003,151 entitled SIP-IOS ADAPTER FUNCTION filed on Nov. 15, 2007, the disclosure of each of which is incorporated in its entirety herein by reference.

### FIELD OF THE INVENTION

The present invention is generally related to radio access technologies and, more particularly, to mechanisms for Internet protocol (IP) provisioning of a femtocell radio access network.

### BACKGROUND OF THE INVENTION

Contemporary cellular radio systems, or mobile telecommunication systems, provide an over-the-air interface to wireless user equipments (UEs) via a radio access network (RAN) that interfaces with at least one core network. The RAN may be implemented as, for example, a CDMA2000 RAN, a Universal Mobile Telecommunications System (UMTS) RAN, a Global System for Mobile communications (GSM) RAN, or another suitable radio access network implementation. The UEs may comprise, for example, a mobile terminal such as a mobile telephone, a laptop computer featuring mobile telephony software and hardware, a personal digital assistant (PDA), or other suitable equipment adapted to transfer and receive voice or data communications with the radio access network.

A RAN covers a geographical area comprised of any number of cells each comprising a relatively small geographic area of radio coverage. Each cell is provisioned by a cell site that includes a radio tower, e.g., a base transceiver station (BTS), and associated equipment. BTSs communicate with UEs over an air interface within radio range of the BTSs.

Numerous BTSs in the RAN may be communicatively coupled to a base station controller, also commonly referred to as a radio network controller (RNC). The BSC manages and monitors various system activities of the BTSs serviced thereby. BSCs are typically coupled with at least one core network.

BTSs are typically deployed by a carrier network in areas having a high population density. The traffic capacity of a cell site is limited by the site's capacity and affects the spacing of cell sites. In suburban areas, sites are often up to two miles apart, while cell sites deployed in dense urban areas may be as close as one-quarter of a mile apart. Because the traffic capacity of a cell site is finitely limited, as is the available frequency spectrum, mobile operators have a vested interest in technologies that allow for increased subscriber capacity.

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A microcell site comprises a cell in a mobile phone network that covers a limited geographic area, such as a shopping center, hotel, airport, or other infrastructure that may have a high density mobile phone usage. A microcell typically uses power control to limit the radius the microcell coverage. Typically a microcell is less than a mile wide.

Although microcells are effective for adding network capacity in areas with high mobile telephone usage, microcells extensively rely on the RAN, e.g., a controlling BSC and other carrier functions. Because contemporary BSCs have limited processing and interface capacity, the number of BTSs—whether microcell BTSs or typical carrier BTSs—able to be supported by the BSC or other RAN functions is disadvantageously limited.

Contemporary interest exists in providing enterprise and office access, including small office/home office (SOHO) radio access, by an even smaller scale BTS. The radio coverage area of such a system is typically referred to as a femtocell. In a system featuring a femtocell, a UE may be authorized to operate in the femtocell when proximate the femtocell system, e.g., while the UE is located in the SOHO. When the UE moves beyond the coverage area of the femtocell, the UE may then be serviced by the carrier network. The advantage of deployment of femtocells are numerous. For instance, mobile users frequently spend large amounts of time located at, for example, home, and many such users rely extensively on cellular network service for telecommunication services during these times. For example, a recent survey indicated that nearly thirteen percent of U.S. cell phone customers do not have a landline telephone and rely solely on cell phones for receiving telephone service. From a carrier perspective, it would be advantageous to have telephone services provisioned over a femtocell system, e.g., deployed in the user's home, to thereby reduce the load, and effectively increase the capacity, on the carrier RAN infrastructure. However, due the large potential demand for femtocell systems, contemporary BTS interface mechanisms with a RAN via BSCs or equivalent RNCs is impractical due to scaling issues.

Therefore, what is needed is a mechanism that overcomes the described problems and limitations.

### SUMMARY OF THE INVENTION

The present invention provides a system, method, and computer readable medium for provisioning radio access via a femtocell system that includes integrated BTS and BSC functions. The femtocell system is coupled with a packet switched backhaul and provides an IP-accessible radio access network. The femtocell system includes a session initiation protocol (SIP) adapter that supports a SIP client pool and provides conversion of call set-up functions to SIP client set-up functions for provisioning of radio access to a user equipment. A user equipment may have a session initiation protocol client associated with the user equipment. The session initiation protocol client is hosted and registered with a registrar service by the femtocell system. Accordingly, telecommunication services may be directed to and from the user equipment over the packet-switched backhaul to the user equipment via the femtocell system.

In one embodiment of the disclosure, a method for providing radio access network service is provided. The method comprises communicatively coupling a femtocell system with a packet-switched backhaul, allocating, by the femtocell system, a session initiation protocol client for a user equipment, and transmitting, by the femtocell system, a first registration message for the client, wherein the first registration



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message includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment.

In another embodiment of the disclosure, a computer-readable medium having computer-executable instructions for execution by a processing system, the computer-executable instructions for providing radio access network service, is provided. The computer-readable medium comprises instructions for communicatively coupling a femtocell system with a packet-switched backhaul, allocating, by the femtocell system, a session initiation protocol client for a user equipment, and transmitting, by the femtocell system, a first registration message for the client, wherein the first registration message includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment, and wherein the first registration message further includes a second contact comprising a telephone uniform resource identifier comprising a telephone number assigned to the user equipment.

In a further embodiment of the disclosure, a system for providing radio access network service is provided. The system comprises a radio access network including a base transceiver station adapted to provide communication services over a first air interface with a user equipment, wherein the first air interface is provisioned by a base transceiver station providing a macrocell. The system further includes a packet-switched network having a domain with which the user equipment has a session initiation protocol service subscription, and an Internet Protocol multimedia subsystem communicatively interfaced with the radio access network and the packet-switched network. The system further includes a femtocell system communicatively coupled with the packet-switched network and having an Internet protocol address assigned thereto. The femtocell system allocates a session initiation protocol client for the user equipment, transmits a first registration message for the client that includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment, wherein the femtocell system further registers a second contact comprising a telephone uniform resource identifier comprising a telephone number assigned to the user equipment, and wherein the order of the first contact and the second contact specifies a preferred contact order for the user equipment.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures, in which:

FIG. 1 is a diagrammatic representation of a network system that includes a cellular network adapted to provide macro-cellular coverage;

FIG. 2 is a diagrammatic representation of a conventional network system configuration featuring a femtocell;

FIG. 3 is a diagrammatic representation of a network system in which a femtocell system implemented in accordance with an embodiment of the present invention may be deployed;

FIG. 4 is a diagrammatic representation of a network system in which a femtocell system implemented in accordance with an alternative embodiment of the invention may be deployed;

FIG. 5A is a simplified diagrammatic representation of femtocell system depicted in FIG. 3 that may be connected with an IP backhaul in accordance with an embodiment;

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FIG. 5B is a simplified diagrammatic representation of an alternative embodiment of a femtocell system that may be connected with an IP backhaul; and

FIG. 6 is a diagrammatic representation of an exemplary session initiation protocol registration message generated by a femtocell system on behalf of a user equipment in accordance with an embodiment.

#### DETAILED DESCRIPTION OF THE INVENTION

It is to be understood that the following disclosure provides many different embodiments or examples for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting.

FIG. 1 is a diagrammatic representation of a network system **100** that includes a cellular network **110** adapted to provide macro-cellular coverage to a user equipment. Cellular network **110** may comprise, for example, a code-division multiple access (CDMA) network, such as a CDMA-2000 network.

Cellular network **110** may include any number of base transceiver stations (BTSs) **112a-112c** communicatively coupled with a base station controller (BSC) **114** or RNC. Each individual BTS **112a-112c** under the control of a given BSC may define a radio cell operating on a set of radio channels thereby providing service to a user equipment (UE) **125**, such as a mobile terminal. BSC **114** manages the allocation of radio channels, receives measurements from mobile terminals, controls handovers, as well as various other functions as is understood. BSC **114** is interconnected with a mobile services switching center (MSC) **116** that provides mobile terminal exchange services. BSC **114** may be additionally coupled with a packet data serving node (PDSN) **118** or other gateway service that provides a connection point between the CDMA radio access network and a packet network, such as Internet **160**, and provides mobility management functions and packet routing services. MSC **116** may communicatively interface with a circuit switched network, such as the public switched telephone network (PSTN) **150**, and may additionally be communicatively coupled with an interworking function (IWF) **122** that provides an interface between cellular network **110** and PSTN **150**.

System **100** may also include a signaling system, such as a signaling system #7 (SS7) network **170**. SS7 network **170** provides a set of telephony signaling protocols which are used to set up the vast majority of the world's PSTN telephone calls. SS7 network **170** is also used in cellular networks for circuit switched voice and packet-switched data applications. As is understood, SS7 network **170** includes various signaling nodes, such as any number of service control points (SCPs) **172**, signal transfer points (STPs) **174**, and service switching points (SSPs) **176**.

BTSs **112a-112c** deployed in cellular network **110** may service numerous network **110** subscribers. Cell sites provided by BTSs **112a-112c** commonly feature site ranges of a quarter to a half mile, e.g., in densely populated urban areas, to one to two miles in suburban areas. In other remotely populated regions with suitable geography, site ranges may span tens of miles and may be effectively limited in size by the limited transmission distance of relatively low-powered UEs. As referred to herein, a cell provided by a BTS deployed in carrier network **110** for access by any authorized network **110** subscriber is referred to as a macrocell.

FIG. 2 is a diagrammatic representation of a conventional network system **200** configuration featuring a femtocell. In

the depicted example, a central BSC **214** deployed in a cellular carrier network **210** may connect with a soft switch core **212** that is connected with a MSC **216**. MSC **216** connects with the cellular core network and may interface with other networks, such as the PSTN as is understood. BSC **214** may be connected with and service numerous BTSs **212a-212c** that provide macrocells to cellular network **210** subscribers.

BSC **214** may additionally connect with a tunnel gateway system **218** that is adapted to establish secured tunnels **232a-232x** with respective femtocell systems **250a-250x**. Femtocells comprise cellular access points that connect to a mobile operator's network using, for example, a residential DSL or cable broadband connection. Femtocells **250a-250x** provide a radio access point for UE **225** when the UE is within range of a femtocell system with which the UE has authorized access. For example, femtocell system **250a** may be deployed in a residence of the user of UE **225**. Accordingly, when the user is within the residence, mobile telecommunications may be provided to UE **225** via an air-interface provided by femtocell system **250a**. In this instance, UE **225** is effectively offloaded from the macro BTS, e.g., BTS **212a**, and communications to and from the UE are carried out with femtocell system **250a** over Internet **260**. Thus, femtocell systems **250a-250x** may reduce the radio resource demands by offloading UEs from macrocells to femtocells and thereby provide for increased subscriber capacity of cellular network **210**.

In contemporary implementations such as that depicted in FIG. 2, a femtocell system **250a** comprises a transceiver without intelligence and is thus required to be connected and managed by BSC **214**. Thus, femtocell systems **250a-250x** are reliant on the carrier network centralized BSC **214** which has limited capacity and thus does not exhibit desirable scaling characteristics or capabilities. Moreover, high communications overhead are realized by the BTS backhaul.

FIG. 3 is a diagrammatic representation of a network system **300** in which a femtocell system implemented in accordance with an embodiment of the invention may be deployed. System **300** includes a radio access network (RAN) **310** that provides an over-the-air interface with a UE **325**, e.g., a mobile terminal. RAN **310** may comprise, for example, a CDMA radio access network or another suitable RAN. RAN **310** may comprise various BTSs and associated base station controllers BSCs as well as other infrastructure as is understood. UE **325** may be implemented as a personal digital assistant (PDA), a mobile phone, a computer, or another device adapted to interface with RAN **310**.

System **300** may include an IP Multimedia Subsystem (IMS) **320** architecture adapted to provide IP service to UE **325**. To this end, RAN **310** is communicatively coupled with a serving general packet radio service (GPRS) support node (SGSN) **314** and a gateway GPRS support node (GGSN) **316**. SGSN **314** provides the delivery of data packets from and to UE **325** within its service area. GGSN **316** provides an interface between the GPRS backbone network and external packet data networks. GGSN **316** is communicatively coupled with a policy decision function (PDF) **318** that provides authorization of media plane resources, e.g., quality of service (QoS) authorizations, policy control, bandwidth management, and the like. PDF **318** may be communicatively coupled with a call session control function (CSCF) **320**.

CSCF **320** comprises various session initiation protocol (SIP) servers or proxies that process SIP signaling packets in IMS **320**. CSCF **320** may include a proxy-CSCF (P-CSCF) that provides a first point of contact for an IMS-compliant UE. The P-CSCF may be located in the visited network, or in the UE's home network if the visited network is not fully

IMS-compliant. UE **325** may discover the P-CSCF, e.g., by using Dynamic Host Configuration Protocol (DHCP), or by assignment in a packet data protocol (PDP) context. CSCF **320** additionally includes a Serving-CSCF (S-CSCF) that comprises the central node of the signaling plane. The S-CSCF comprises a SIP server, but additionally performs session control. The S-CSCF is located in the home network and interfaces with a home subscriber server (HSS) **340** to download and upload user profiles. CSCF **320** further includes an Interrogating-CSCF (I-CSCF) that comprises a SIP function located at the edge of an administrative domain. The I-CSCF has an IP address that is published in the Domain Name System (DNS) **372** that facilitates location of the I-CSCF by remote servers. Thus, the I-CSCF is used as a forwarding point for receipt of SIP packets within the domain.

HSS **340** comprises a user database that supports the IMS network entities that manage calls. HSS **340** stores user profiles that specify subscription-related information of authorized users, authenticates and authorizes users, and provides information about the user's physical location. Various application servers (AS) **342a-342n** that host and execute services interface with CSCF **320** via SIP.

CSCF **320** is coupled with a breakout gateway control function (BGCF) **322** that comprises a SIP server that provides routing functionality based on telephone numbers. BGCF **322** is used when a UE places a call from the IMS to a phone in a circuit switched network, e.g., PSTN **330**, or the public land mobile network. A media gateway controller Function (MGCF) **324** performs call control protocol conversion between SIP and ISDN User Part (ISUP) and interfaces with a signaling gateway (SGW) **326**. SGW **326** interfaces with the signaling plane of a circuit switched network, e.g., PSTN **330**. SGW **326** may transform lower layer protocols, such as Stream Control Transmission Protocol (SCTP), into the Message Transfer Part (MTP) protocol, and pass ISUP data from MGCF **324** to PSTN **330** or another circuit switched network. A media gateway (MGW) **328** interfaces with the media plane of PSTN **330** or another circuit switched network by converting data between real-time transport protocol (RTP) and pulse code modulation (PCM), and may also be employed for transcoding when the codecs of the IMS and circuit switched networks differ. Resources of MGW **328** are controlled by MGCF **324**. Fixed access, e.g., IP telephony devices **374a-374b**, may connect with IMS network via Internet **370** that is communicatively coupled with IMS network **320** by way of border gateway **360**.

As is understood, DNS **372** comprises a scalable namespace that facilitates access to entities deployed on the Internet or private networks. DNS **372** maintains various records for host names, servers, and the like. For example, DNS **372** maintains records (commonly referred to as "A records") that map hostnames to IP addresses, pointer (PTR) records that map IP addresses to canonical names to facilitate reverse DNS lookups, service (SRV) records that specify information on available services, naming authority pointer (NAPTR) records that facilitate regular expression based rewriting, and various other records. DNS **372** may additionally include a telephone number mapping (ENUM) system that facilitates resolution of SIP addresses from E.164 number as is understood.

In accordance with an embodiment, a femtocell system **350** may include integrated BTS and BSC functions and may feature additional capabilities available in the provided femtocell site coverage area. Femtocell system **350** provides an IP-accessible radio access network, is adapted for operation with IMS **320**, and provides radio link control functions.

Femtocell system 350 may be communicatively coupled with Internet 370 via any variety of backhaul technologies, such as an 802.11x link, a 10/100 BaseT LAN link, a T1/E1 Span or fiber, cable set top box, DSL modem connected with a central office digital subscriber line access multiplexer, a very small aperture terminal (VSAT), or another suitable backhaul infrastructure.

In an embodiment, femtocell system 350 includes a session initiation protocol (SIP) adapter that supports a SIP client pool and provides conversion of call set-up functions to SIP client set-up functions. Additionally, femtocell system 350 includes electronic serial number (ESN) screening and/or Mobile Equipment Identifier (MEID) screening to allow only designated UEs to access the femtocell thereby restricting access to authorized home or small office UEs. Provisioning of ESN(s) or MEIDs may be made as part of an initial femtocell system 350 activation. In the illustrative example, femtocell system 350 is allocated an Internet Protocol (IP) address of "66.249.73.42", and UE 325 is allocated a mobile services ISDN (MSISDN) number, or E.164 number, of "12145551212".

FIG. 4 is a diagrammatic representation of a network system 400 in which a femtocell system implemented in accordance with an alternative embodiment of the invention may be deployed. System 400 includes a radio access network (RAN) 410 that provides an over-the-air interface with a UE 325, e.g., a mobile terminal. RAN 410 may comprise, for example, a Universal Mobile Telecommunications System (UMTS) network that implements, for example, a CDMA2000 air interface. To this end, UE 325 may be implemented as a 3G-compliant handset. RAN 410 comprises various radio network controllers (RNCs), radio nodes (RNs), also referred to as "Node Bs", as well as other infrastructure as is understood.

One or more RNCs of RAN 410 provide an interface between RAN 410 and a circuit switched network 430, such as the PSTN or a circuit-switched cellular network, and a packet-switched network 420, such as the Internet. RNCs of RAN 410 may interface with the circuit-switched network 430 via a media gateway (MGW) 460 and may interface with the packet-switched network 420 via a Serving GPRS Support Node (SGSN) 462. SGSN 462 provides the delivery of data packets from and to UE 325 when UE 325 is located within its service area. DNS 472 facilitates access to entities deployed on the Internet or private networks as is understood.

In accordance with an embodiment, a femtocell system 450 may be implemented as a 3G-complinat entity, e.g., to service UMTS mobile terminals, and may be deployed in a SOHO or other suitable enterprise. To this end, femtocell system 450 may include an integrated RNC and RN. In a particular implementation, femtocell system 450 may be implemented as an Evolution-Data Optimized (EV-DO) entity, e.g., a 1xEV-DO integrated IP-RAN. Femtocell system 450 provides an IP-accessible radio access network and provides radio link control functions and may directly connect with a SIP switch 480, e.g., via an Ethernet backhaul or another suitable backhaul infrastructure. SIP switch 480 may include or interface with various application servers and, in general, includes or interfaces with a location server 482 as well as registrar, redirect, and proxy servers as is understood. SIP switch 480 may be communicatively interfaced with RAN 410 and circuit-switched network 430 via suitable gateways.

Similar to femtocell system 350 described above, femtocell system 450 includes a session initiation protocol (SIP) adapter that supports a SIP client pool and provides conversion of call set-up functions to SIP client set-up functions. Additionally, femtocell system 450 includes ESN or MEID

screening to allow only designated UEs to access the femtocell thereby restricting access to authorized home or small office UEs. Provisioning of ESN(s) or MEID(s) may be made as part of an initial femtocell system activation.

FIG. 5A is a simplified diagrammatic representation of femtocell system, such as femtocell 350 depicted in FIG. 3, that facilitates provisioning of a femto-RAN in accordance with an embodiment. Femtocell system 350 includes an antenna 500 coupled with a BTS 510. BTS 510 may be implemented, for example, as a 1xRTT ASIC device and may comprise a non-diversity receiver featuring a built-in duplexer. In an embodiment, BTS 510 may feature only one operational band and may include a transmitter scan receiver and local oscillator. BTS 510 may be communicatively coupled with a BSC 520 that provides radio control functions, such as receiving measurements from UEs, such as mobile phones, control of handovers to and from other femtocell systems, and may additionally facilitate handoff to or from macrocells.

Femtocell system 350 includes an electronic serial number screening function 530 that may facilitate approving or rejecting service for a UE by femtocell system 350. Additionally femtocell system 350 includes an Internet Operating System (IOS) and SIP Adapter (collectively referred to as IOS-SIP Adapter 540). IOS-SIP adapter 540 may invoke and manage SIP clients, such as a user agent (UA) pool comprising one or more UAs. In accordance with an embodiment, each UE 325 authorized to be serviced by femtocell system 350 may have a UA allocated therefor by femtocell system 350 in a manner that facilitates transmission of communications to and from a UE over an IP backhaul. Accordingly, when an authorized UE is within the femtocell system 350 site range, telecommunication services may be provided to the UE via the IP backhaul and femtocell system 350 provisioned RAN. When the UE is moved beyond the service range of femtocell system 350, telecommunication service may then provided to the UE via macrocellular coverage.

To facilitate routing of calls from circuit switched call originators, femtocell system 350 may perform a DNS/ENUM registration on behalf of UEs authorized to obtain service from femtocell system 350. In the present example, assume UE 325 with a MSISDN of "12145551212" has a SIP service subscription in the domain "example.com" and has a SIP uniform resource identifier (URI) of "12145551212@example.com". An example DNS/ENUM registration message generated by femtocell system 350 on behalf of UE 325 and transmitted to DNS 372 is as follows:

```
SORIGIN 2.1.2.1.5.5.5.4.1.2.1.e164.arpa.  
IN NAPTR 100 10 "u" "E2U+sip" "!.*!$!sip:  
12145551212@example.com!"
```

As is understood, the first line of the registration message comprises the MSISDN number of the UE converted (i.e., reversed with each numeral delineated with a "." character and appended with the e164.arpa domain) for DNS lookup. The second line of the registration message specifies the NAPTR record for the hosts that can further process the address—the domain "example.com" (in which the UE with a URI of 12145551212@example.com is registered) in the present example.

In accordance with another embodiment, femtocell system 350 may generate and issue a SIP registration on behalf of UE 325 authorized for service access by femtocell system 350.

FIG. 5B is a simplified diagrammatic representation of femtocell system 450 depicted in FIG. 4 that facilitates provisioning of a femto-RAN in accordance with an alternative embodiment. Femtocell system 450 includes an antenna 500 coupled with a RN 511. RN 511 may be implemented, for

example, as a 1xEV-DO ASIC device. For example, RN **511** may provide a 1xEV-DO Rev. 0 air interface or a 1xEV-DO Rev. A air interface. RN **511** may be communicatively coupled with a RNC **521** that provides radio control functions, such as receiving measurements from UEs, control of handovers to and from other femtocell systems, and may additionally facilitate handoff to or from macrocells. RNC **521** may also provide encryption/decryption functions, power, load, and admission control, packet scheduling, and various other services.

Femtocell system **450** includes an electronic serial number screening function **530** that may facilitate approving or rejecting service for a UE by femtocell system **450**. Additionally, femtocell system **450** includes an Internet Operating System (IOS) and SIP Adapter (collectively referred to as IOS-SIP Adapter **540**). IOS-SIP adapter **540** may invoke and manage SIP clients, such as a user agent (UA) pool comprising one or more UAs. Each UE **425** authorized to be serviced by femtocell system **450** may have a UA allocated therefor by femtocell system **450** in a manner that facilitates transmission of communications to and from a UE over an IP backhaul. Accordingly, when an authorized UE is within the femtocell system **450** site range, telecommunication services may be provided to the UE via the IP backhaul and the femtocell system **450** provisioned RAN. When the UE is moved beyond the service range of femtocell system **450**, telecommunication service may then be provided to the UE via macrocellular coverage. Femtocell system **450** may perform a DNS/ENUM registration on behalf of UEs authorized to obtain service from femtocell system **450** and may generate and issue a SIP registration on behalf of a UE authorized for service access by the femtocell system **450** in a manner similar to that described above with reference to femtocell system **350**.

FIG. 6 is a diagrammatic representation of an exemplary SIP registration message **600** generated by femtocell system **350** on behalf of UE **325** authorized for service access thereby in accordance with an embodiment. Registration message may be transmitted from femtocell system **350** to a SIP registrar service, e.g., to SIP Registrar **380** via CSCF **320**. Registrar **380** may provide the location and contact information to location service **382**. Registration message **600** includes a REGISTER field **610** that specifies the registration is being made within the domain "example.com". In accordance with an embodiment, multiple contacts are included in registration message **600**. In the present example, registration message **600** includes a contact field **612** that specifies a SIP contact for UE **325**. Notably, the SIP contact field **612** for UE **325** specifies the UA registered on behalf of UE with the URI 12145551212@example.com is located at the IP address of "66.249.73.42". That is, the SIP contact registered by femtocell system **350** on behalf of UE **325** is to be addressed at the femtocell system **350** address of 66.249.73.42 thereby resulting in routing of SIP signaling messages to femtocell system **325**. In turn, femtocell system **350** may convert SIP call set up messaging to RAN signaling, allocate an uplink and a downlink channel for UE **325**, and set up a call or data session thereon.

In the present example, registration message **600** includes a second contact field **614** that specifies a telephone URI, e.g., the MSISDN +1-214-555-1212 of UE **325**. Thus, a location query for the SIP URI sip:12145551212@example.com would return two contacts. The first is the SIP URI that can be used to reach femtocell system **350**, and thus UE **325** thereby, and the second is the telephone URI that can be used to reach UE **325** via macrocellular coverage, i.e., via RAN **310**. As is understood, the order of contacts **612-614** provides a contact preference. As is understood, the multiple contacts may be

registered in separate registration messages, and the depicted registration message including both the SIP contact URI and telephone URI is exemplary only. Accordingly, in the present example, an attempt to contact UE **325** may first be made via the SIP URI 12145551212@example.com. In the event that the session is not successfully set up via the SIP contact, an attempt may be made to setup a session via RAN **310**.

When the UE **325** moves outside the coverage area of femtocell system **350**, another registration may be generated and submitted by femtocell system **350** on behalf of UE where the telephone URI is designated as the preferred contact. Further, the SIP URI may be removed from the registration when the UE **325** moves outside the coverage area of femtocell system **350** thereby avoiding any attempts to establish a session with UE **325** via femtocell system **350** when UE **325** has moved beyond the femtocell system **350** coverage area.

To better facilitate an understanding of disclosed embodiments, consider a call placed at circuit switched telephone **332** to UE **325**. A gateway receives the call setup request, e.g., an Initial Address Message (IAM), and a query may be made with DNS **372** from which the domain "example.com" is resolved from the ENUM function. An INVITE message is then transmitted to the example.com domain which, in turn, resolves the location of the called UE **325**. Particularly, CSCF **320** may interrogate location server **382** and determine UE **325** is registered as located at the IP address 66.249.73.42. Accordingly, the INVITE message is routed to proxy server **376** which forwards the INVITE message to femtocell system **350**. Femtocell system **350** may then perform paging, channel allocation, and other procedures for provisioning a radio interface with UE **325** and issue SIP responses on behalf of UE **325**. Thus, from a network perspective, femtocell system **350** appears as a user equipment to which the call is directed. Further, UE **325** does not require a SIP client for receiving the call because femtocell system **350** advantageously performs signaling and media conversion for signaling and media transmissions over the air interface with **325**. To this extent, femtocell system **350** may appear as a conventional BTS to UE **325**. A call from UE **325** to another terminal, such as circuit-switched telephone **332**, a SIP client such as packet-switched telephony device **374a**, or another device, may similarly be facilitated by femtocell system **350**.

As a second example, assume UE **325** has moved beyond the range of femtocell system **350**. As noted above, femtocell system **350** may generate and transmit a registration message that excludes the SIP contact to facilitate provisioning of telecommunication services via macrocell coverage, e.g., via RAN **310**. For instance, femtocell system **350** may periodically perform power measurements with UE **325**, and upon the power measurement dropping below a particular power threshold, femtocell system may determine UE **325** is to be serviced by macrocellular coverage. Alternatively, a user may select macrocellular coverage via a user interface provided on UE **325**. In this instance, UE **325** may provide an indication to femtocell system **350** that telecommunication services are to be provided by RAN **310**. Other scenarios may similarly result in a determination that UE **325** is to be serviced by RAN **310**. Upon such a determination, femtocell system **350** may generate and transmit a registration message on behalf of UE **325** to a registrar service, e.g., CSCF **320** and SIP registrar **380**. The contact information may then be updated in location server **382** to indicate the telephone URI as the contact of UE **325**. In this scenario, consider a call placed at circuit switched telephone **332** to UE **325**. A gateway receives the call setup request, e.g., an Initial Address Message (IAM), and a query may be made with DNS server **372** from which the domain

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"example.com" is resolved from the ENUM service. An INVITE message is then transmitted to the example.com domain which resolves the location of called UE 325. In the present example, CSCF 320 may interrogate location server 382 and determine UE 325 has a preferred contact registered as a telephone URI of 2145551212. Accordingly, the INVITE message is routed to a gateway server, e.g., gateway server 390 which translates the INVITE message to a RAN-compliant call request signaling. The call may then be setup via RAN 310 accordingly.

As described, mechanisms for provisioning radio access via a femtocell system that includes integrated BTS and BSC functions are provided. The femtocell system is coupled with a packet switched backhaul and provides an IP-accessible radio access network. The femtocell system includes a session initiation protocol (SIP) adapter that supports a SIP client pool and provides conversion of call set-up functions to SIP client set-up functions for provisioning of radio access to a user equipment. A user equipment may have a session initiation protocol client associated with the user equipment. The session initiation protocol client is hosted and registered with a registrar service by the femtocell system. Accordingly, telecommunication services may be directed to and from the user equipment over the packet-switched backhaul to the user equipment via the femtocell system.

The illustrative block diagrams depict process steps or blocks that may represent modules, segments, or portions of code that include one or more executable instructions for implementing specific logical functions or steps in the process. Although the particular examples illustrate specific process steps or procedures, many alternative implementations are

possible and may be made by simple design choice. Some process steps may be executed in different order from the specific description herein based on, for example, considerations of function, purpose, conformance to standard, legacy structure, user interface design, and the like.

Aspects of the present invention may be implemented in software, hardware, firmware, or a combination thereof. The various elements of the system, either individually or in combination, may be implemented as a computer program product tangibly embodied in a machine-readable storage device for execution by a processing unit. Various steps of embodiments of the invention may be performed by a computer processor executing a program tangibly embodied on a computer-readable medium to perform functions by operating on input and generating output. The computer-readable medium may be, for example, a memory, a transportable medium such as a compact disk, a floppy disk, or a diskette, such that a computer program embodying the aspects of the present invention can be loaded onto a computer. The computer program is not limited to any particular embodiment, and may, for example, be implemented in an operating system, application program, foreground or background process, driver, network stack, or any combination thereof, executing on a single processor or multiple processors. Additionally, various steps of embodiments of the invention may provide one or more data structures generated, produced, received, or otherwise implemented on a computer-readable medium, such as a memory.

Although embodiments of the present invention have been illustrated in the accompanying drawings and described in the foregoing description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth

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and defined by the following claims. For example, the capabilities of the invention can be performed fully and/or partially by one or more of the blocks, modules, processors or memories. Also, these capabilities may be performed in the current manner or in a distributed manner and on, or via, any device able to provide and/or receive information. Further, although depicted in a particular manner, various modules or blocks may be repositioned without departing from the scope of the current invention. Still further, although depicted in a particular manner, a greater or lesser number of modules and connections can be utilized with the present invention in order to accomplish the present invention, to provide additional known features to the present invention, and/or to make the present invention more efficient. Also, the information sent between various modules can be sent between the modules via at least one of a data network, the Internet, an Internet Protocol network, a wireless source, and a wired source and via plurality of protocols.

What is claimed is:

1. A method, comprising:

allocating, by a femtocell system, a session initiation protocol client for a user equipment; and  
transmitting, by the femtocell system, a first registration message for the client, wherein the first registration message includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment, wherein the first registration message includes a second contact comprising a telephone uniform resource identifier;

wherein the telephone uniform resource identifier comprises a telephone number assigned to the user equipment, and wherein the order of the first contact and the second contact specifies a preferred contact order for the use equipment;

comprising transmitting, by the femtocell system, a second registration message for the client to a registrar service, wherein the second registration message includes a first contact comprising a telephone uniform resource identifier comprising a telephone number assigned to the user equipment, and wherein telecommunication services are provided to the user equipment by a macrocellular system subsequent to transmission of the second registration message.

2. The method of claim 1, comprising registering the user equipment with a domain name system server that associates a telephone number of the user equipment with a domain in which the user equipment has a session initiation protocol service subscription.

3. The method of claim 1, comprising:

receiving, by the femtocell system, a session initiation protocol call set-up message specifying the session initiation protocol uniform resource identifier as a recipient;

converting the session initiation protocol set-up message into a radio access network-compliant signaling message; and

transmitting the radio access network-compliant signaling message over an air interface to the user equipment.

4. The method of claim 1, comprising:

receiving, by the femtocell system, a signaling message comprising a call set-up request over an air interface from the user equipment, wherein the signaling message comprises a radio access network-compliant signaling message;

converting the call set-up request into a session initiation protocol request message that includes the session ini-

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tiation protocol uniform resource identifier as an originator of the session initiation protocol request message; and

transmitting the session initiation protocol request message over a packet-switched backhaul communicably coupled to the femtocell system.

5. The method of claim 1, wherein the session initiation protocol client comprises a user agent.

6. A non-transitory computer-readable medium having computer-executable instructions for execution by a processing system, the computer-readable medium comprising instructions for:

allocating, by a femtocell system, a session initiation protocol client for a user equipment;

transmitting, by the femtocell system, a first registration message for the client, wherein the first registration message includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment, and wherein the first registration message includes a second contact comprising a telephone uniform resource identifier;

wherein the telephone uniform resource identifier comprises a telephone number assigned to the user equipment, and wherein the order of the first contact and the second contact specifies a preferred contact order for the user equipment;

comprising instructions for transmitting, by the femtocell system, a second registration message for the client with a registrar service, wherein the second registration message includes a first contact comprising a telephone uniform resource identifier comprising a telephone number assigned to the user equipment, and wherein telecommunication services are provided to the user equipment by a macrocellular system subsequent to transmission of the second registration message.

7. The non-transitory computer-readable medium of claim 6, comprising instructions for registering the user equipment with a domain name system server that associates a telephone number of the user equipment with a domain in which the user equipment has a session initiation protocol service subscription.

8. The non-transitory computer-readable medium of claim 6, comprising instructions for:

receiving, by the femtocell system, a session initiation protocol call set-up message specifying the session initiation protocol uniform resource identifier as a recipient;

converting the session initiation protocol set-up message into a radio access network-compliant signaling message; and

transmitting the radio access network-compliant signaling message over an air interface to the user equipment.

9. The non-transitory computer-readable medium of claim 6, comprising instructions for:

receiving, by the femtocell system, a signaling message comprising a call set-up request over an air interface from the user equipment, wherein the signaling message comprises a radio access network-compliant signaling message;

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converting the call set-up request into a session initiation protocol request message that includes the session initiation protocol uniform resource identifier as an originator of the session initiation protocol request message; and

transmitting the session initiation protocol request message.

10. The non-transitory computer-readable medium of claim 6, wherein the session initiation protocol client comprises a user agent.

11. A system, comprising:

a radio access network including a base transceiver station adapted to provide communication services over a first air interface with a user equipment, wherein the first air interface is provisioned by a base transceiver station;

a packet-switched network having a domain with which the user equipment has a session initiation protocol service subscription; and

a femtocell system communicatively coupled with the packet-switched network and having an internet protocol address assigned thereto, wherein the femtocell system allocates a session initiation protocol client for the user equipment, transmits a first registration message for the client that includes a first contact comprising a session initiation protocol uniform resource identifier assigned to the user equipment, wherein the femtocell system registers a second contact comprising a telephone uniform resource identifier;

wherein the telephone uniform resource identifier comprises a telephone number assigned to the user equipment, and wherein the order of the first contact and the second contact specifies a preferred contact order for the user equipment.

12. The system of claim 11, comprising a domain name system server, wherein the femtocell system registers the user equipment with the domain name system server that associates the telephone number of the user equipment with the domain.

13. The system of claim 11, wherein the femtocell system receives at least one session initiation protocol call set-up message specifying the session initiation protocol uniform resource identifier as a recipient, converts the at least one session initiation protocol set-up message into a radio access network-compliant signaling message, and transmits the radio access network-compliant signaling message over an air interface to the user equipment.

14. The system of claim 11, wherein the femtocell system receives a signaling message comprising a call set-up request over an air interface from the user equipment, wherein the signaling message comprises a radio access network-compliant signaling message, converts the call set-up request into a session initiation protocol request message that includes the session initiation protocol uniform resource identifier as an originator of the session initiation protocol request message, and transmits the session initiation protocol request message.

15. The system of claim 11, comprising an Internet Protocol multimedia subsystem communicatively interfaced with the radio access network and the packet-switched network.

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